

#5 1-10-02  
Priority Papers

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Andreas BUOS et al.  
Title: LOUDSPEAKER DRIVER  
Appl. No.: New U.S. Utility Application  
Filing Date: November 7, 2001  
Examiner: Unassigned  
Art Unit: Unassigned



CLAIM FOR CONVENTION PRIORITY

Commissioner for Patents  
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application filed in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed.

In support of this claim, filed herewith is a certified copy of said original foreign application:

- GREAT BRITAIN Patent Application No. 0027278.1 filed 11/08/2000.

Respectfully submitted,

Date NOV 07 2001

By Alan I. Cantor

FOLEY & LARDNER  
Customer Number: 22428



22428

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Signed

*W. Evans*

Dated 18 October 2001

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Patents Act 1977  
(Rule 16)The  
Patent  
Office08NOV00 0027278.1 0027278.1  
08/11/00 0.00-0027278.1

## Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form).

The Patent Office

Cardiff Road  
Newport  
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## 1. Your Reference

P.6531.GBA

## 2. Patent application number

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08 NOV 2000

0027278.1

## 3. Full name, address and postcode of the or of each applicant (underline all surnames)

NEW TRANSDUCERS LIMITED  
IXWORTH HOUSE  
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LONDON  
SW3 3QH

Patents ADP number (if you know it)

07283476002

If the applicant is a corporate body, give the country/state of its incorporation

G.B.

## 4. Title of the invention

LOUDSPEAKER DRIVER

## 5. Name of your agent (if you have one)

"Address for service" in the United Kingdom  
to which all correspondence should be sent  
(including the postcode)MAGUIRE BOSS  
5 Crown Street  
St. Ives  
Cambridgeshire  
PE27 5EB

Patents ADP number (if you know it)

07188725001

## 6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)Date of filing  
(day/month/year)

## 7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
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## 8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
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Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

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11.

I/We request the grant of a patent on the basis of this application.

Signature

Date 08/11/00

  
MAGUIRE BOSS

12. Name and daytime telephone number of person to contact in the United Kingdom

PETER MAGUIRE

Tel: 01480 301588

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DUPLICATE

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TITLE: LOUDSPEAKER DRIVER

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DESCRIPTION

This invention relates to drivers or exciters for loudspeakers, in particular but not exclusively for the class of loudspeakers known as bending wave panel-form loudspeakers, e.g. resonant panel-form speakers of the kind described in WO97/09842.

The technology described in this International application has come to be known as distributed mode or DM technology. Such loudspeakers comprise a resonant panel-form member and a vibration transducer or exciter mounted to the panel-form member to excite resonant bending-wave vibration in the panel-form member.

An example of a known inertial exciter (14) mounted on such a known panel-form member (15) is shown in Figure 1. The exciter (14) comprises a magnet assembly (16) and a voice coil assembly (18). The magnet assembly (16) comprises a magnet (20), a pole piece (22) and a magnet cup

such that the magnet <sup>2</sup>(20) is sandwiched between  
attached to both the pole piece (22) and the magnet cup  
. The voice coil assembly (18) comprises a voice coil  
wound on a former (27) which is attached to a coupler  
g (28).

The voice coil (26) of the exciter (14) is attached to  
panel-form member (15) via the coupler ring (28)  
nted on a mounting surface (30) of the panel-form member  
. The magnet assembly (16) is mounted on the voice  
l assembly (18) by means of a suspension (32) attached  
ween the voice coil former (27) and the magnet cup (24).  
exciter (14) receives signal through audio connections

There are two problems encountered with known mounting  
ods, namely the exciter tends to "creep", i.e. move  
er the effect of gravity and the exciter has a tendency  
introduce rocking modes which degrade power handling,  
ten life, and increase distortion. In addition, the  
er delivery at the lowest frequencies is impaired due to  
gy leaking into the unproductive rocking modes.

It is an object of the invention to provide an  
proved exciter for use in such applications.

According to the present invention, there is provided  
exciter comprising a voice coil assembly, a magnet  
em assembly having a centre of mass, a coupler for  
ating the voice coil assembly on an acoustic radiator



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and suspension means for attaching the magnet assembly to the coupler, the suspension means being generally located in a plane which includes the centre of mass of the magnet assembly.

5 The exciter is thus mounted on the acoustic radiator at or near the centre of the moving mass of the exciter, namely the magnet assembly. In this way, the exciter may have dynamic balance. Thus some of the problems of conventional exciter as outlined above are alleviated. In  
10 particular, suspension drift or creep under the force of gravity for a vertical placement may be alleviated.

The exciter is preferably an inertial exciter.

The suspension means may be a spider formed from a corrugated foil of metal or polymer or a strengthened  
15 cloth. Alternatively, the suspension means may be in the form of an arm type cantilever which may be made from polymer or thin metal e.g. stainless steel or beryllium copper. The suspension means may be made from low corrosion metal alloys for high stress environments. Such  
20 metal alloys are generally resistant to adverse effects of humidity and temperature, are low fatigue and have good long-term stability.

FEA may be used to analyse the optimal cantilever shapes for more uniform structural stress and for longer  
25 operating endurance. The cantilever suspension means may also be designed to provide any one of the following

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benefits, namely compensation for magnetic non linearity of  
the exciter, increased control of asymmetric modes of  
magnet vibration, increased control of maximum excursion of  
the voice coil to prevent overload and increased control of  
5 higher order resonances in the suspension means. The  
parameters of the cantilever suspension means which may be  
varied are shape, area, thickness, contour and stiffness  
along each axis. The cantilever suspension means may be  
formed by thermoforming pressing or moulding, for example,  
10 for foil or thin plate suspension means.

By attaching the exciter to suspension means in the  
plane of the centre of mass of the magnet assembly, a  
portion of the mass of the suspension means may also to the  
mass of the exciter at a driving point on the acoustic  
15 radiator. Accordingly, the design of the exciter should  
take into account the additional mass. Furthermore, the  
shape and geometry of the suspension means may be altered  
to achieve a relatively low mass at the driving point which  
allows for maximum bandwidth from the exciter.

20 The suspension means may be attached to the coupler,  
for example by a screw and stud construction or  
alternatively by use of adhesive to reduce mass.  
Alternatively, the suspension means may be cast or  
moulded integrally with the coupler.

25 The exciter system may further comprise a compliant  
member connected in mechanical series connection between a

5  
region of the coupler local to the voice coil and regions  
of the coupler to which the suspension means is attached or  
electrical lead out connections are located. By adding the  
compliant member, a lower effective mass at the driving  
5 point may be achieved with respect to the electrical lead  
out connections and the suspension means.

The compliant member may have a lower compliance than  
the compliance of the suspension means in order not to  
effect the suspension means. Nevertheless, the compliant  
10 member may act to decouple a proportion of the mass of the  
suspension means at higher frequencies from the voice coil  
assembly. Thus, the compliant section should improve the  
high frequency bandwidth without affecting a main resonance  
of the exciter system. The compliant section may also  
15 introduce a second resonance to the exciter which may  
adjust the overall frequency response of the exciter.

The exciter system may further comprise damping to  
control spurious resonances. The damping may be in the  
form of a resilient layer and/or a visco-elastic layer in  
20 contact with any one of the compliant section or the  
suspension means which may introduce resistive damping.

The magnet assembly may comprise a magnet sandwiched  
between a magnet cup and a pole piece, the cup defining a  
magnet gap around the magnet. The magnet gap may be filled  
25 with retentive fluid of suitable viscosity to damp motion

of the voice coil. Such fluid<sup>6</sup> may also provide thermal dissipation.

The exciter may further comprise a support located towards a periphery of the exciter. The performance of the  
5 exciter may be improved by placement of such a support which is located at a greater radial diameter than for conventional constructions. The additional support may provide improved restoring forces to control residual unwanted asymmetric movement.

10 An exciter according to the present invention may have the following advantages:

- 1) The resonant low frequency action of the exciter may be maximised for beneficial coupling to a bending wave panel form radiator. In particular, the use of a balanced exciter  
15 may produce a spring mass resonator capable of imparting an improved mechanical Force [N] suitable to drive low frequency bending wave panels.
- 2) There may be substantially axially directed motion of the magnet as it moves under reaction forces in the motor  
20 system. Furthermore, since the suspension point is outside the voice coil periphery, the stability of linear magnet movement is enhanced. Thus, a linear imparting of a mechanical Force [N] at the drive point of a panel is provided.
- 25 3) Gap tolerances may be tightened providing greater sensitivity and available force.

4) The exciter may have a substantially reduced height and thus the exciter may be used in slimmer constructions of product.

5) By using a balanced exciter, much stiffer lateral support in both vertical mounting positions of the exciter (i.e. desk top multimedia, picture speaker application ect.) and in horizontal mounting positions (i.e. ceiling speakers etc.) may be provided. Thus, linear distortions caused by unstable support of the voice coil position in the air gap of the magnetic circuit may be prevented.

6) The lead out wire connection may be shifted from the relatively high displacement region of the magnet assembly to the low displacement area in the region of the voice coil assembly. The motion of the magnet is thereby improved while the potential for rattle and fatigue problems for the wire connection is reduced.

The invention is diagrammatically illustrated, by way of example, in the accompanying drawings, in which:-

Figure 1 is a cross-section of a known prior art exciter;

Figure 2 is a cross-section of an exciter according to a first embodiment of the invention;

Figure 3 is an exploded view of the exciter of Figure 2;

Figure 4 is a cross-section of an exciter according to a second embodiment of the invention;

Figure 5 is a cross-section of an exciter according to a third embodiment of the invention;

Figure 6 is a frequency response of a typical panel to which exciters according to the prior art and the present invention have been mounted;

Figure 7 is a graph showing the resonance frequency of the magnet in the exciter used in Figure 1.

Figure 1 shows a known prior art exciter (14) and is described in detail above. As is shown in Figure 1, the suspension (32) is spaced away from the plane of centre of mass (36) of the magnet assembly (16).

Figures 2 and 3 show an exciter (40) according to the present invention. In Figure 2, the exciter (40) is mounted on an acoustic radiator (42). The exciter (40) comprises a magnet assembly (44) and a voice coil assembly (46). The magnet assembly (44) comprises a magnet (48), a pole piece (50) and a magnet cup (52) such that the magnet (48) is sandwiched between and attached to both the pole piece (50) and the magnet cup (52). The voice coil assembly (46) comprises a voice coil (54) wound on a former (55) which is attached to a coupler (56).

The voice coil assembly (46) of the exciter (40) is attached to the acoustic radiator (42) via the coupler (56) mounted on a mounting surface (58) of the acoustic radiator (42). The magnet assembly (44) is mounted on the voice

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coil assembly (46) by means of a suspension spider (60) attached between the coupler (56) and the magnet cup (52).

As shown in Figure 3, the coupler (56) is in the form of a shallow cup and is made of plastics. The coupler (56) has a generally disc-like base (57) which provides a large bonding area for mounting on the acoustic radiator (40) and a side wall (63) running around the circumference of and at an angle of approximately 45° to the plane of the base. Three individual mounting provisions (64) project from the top of the side wall (63) and are equally spaced around the circumference of the base. The mounting provisions (64) are generally cylindrical. A fourth projection (65) which is generally flat with a larger surface area than that of the cylindrical mounting provisions (64) also projects from the side wall (63) and may be used to support the connections (not shown).

The suspension spider (60) is in the form of a ring having three arms (67). The suspension spider (60) may be considered to be in the form of a metal cantilever suspension. The ring of the suspension spider (60) is fixed to the outside of the magnet cup (52). One end of each arm (67) carries a suspension point (68), each of which coincide with one of the three individual mounting provisions (64) on the coupler (56). The coupler (56) may be fixed to the metal cantilever suspension by soldering tags.

As shown in Figure 2<sup>10</sup> and in contrast to the prior art exciter (14) of Figure 1, the suspension points (68) are in the plane of the centre of mass (66) of the exciter. Thus, the exciter is balanced and the problems of "creep" and unwanted rocking modes should be alleviated.

The exciter (40) is light weight, slim and robust exciter with a 25 mm diameter and 4 ohm impedance. The voice coil (54) is short. The exciter (40) receives signals through audio connections (62) mounted on one of the mounting provisions (64).

Figure 4 shows an exciter (70) similar to the exciter (40) of Figure 2 but having a reduced thickness. The exciter (70) has a magnet assembly (74) comprising a magnet (78), a pole piece (80) and a magnet cup (82) and a voice coil assembly (76) having a voice coil (84) wound on a coil former (85). The coil former (85) is attached to an acoustic radiator (72) via a coupler (86) which is also attached to the magnet cup (82) via a concentric suspension (90). The suspension (90) is in the plane of the centre of mass (96) of the magnet assembly (74).

The exciter (70) achieves a low profile by using a shorter coil former than that used in the exciter (40) of Figure 2. The coupler (86) is also adapted to provide a shallower profile. The coupler (86) is in the form of a shallow cup having a generally disc-like base (87) and a side wall (88) running around the circumference of and



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having a lower portion at an angle of approximately 30°  
to the plane of the base. The side wall (88) has a top  
portion generally perpendicular to the plane of the base.  
The suspension (90) is attached to the upper portion of the  
3 side wall.

Figure 5 shows an exciter (98) similar to the exciter  
(40) of Figure 2 but having an annular compliant member  
(97) incorporated into the side wall (63) of the coupler  
(56). The compliant member (97) has a lower compliance than  
10 the compliance of the suspension spider (60).

Figure 6 shows two frequency response curves (10,12).  
The lower curve (10) shows a frequency response of an  
acoustic radiator to which a standard exciter (for example,  
the exciter of Figure 1) having a diameter of 25 mm and a  
15 resistance of 4 ohm has been mounted. The inertial exciter  
is mounted using a resin coated fabric cloth suspension.  
The upper curve (12) shows a frequency response of a  
radiator to which a balanced exciter according to the  
invention (for example, the exciter of Figure 2) has been  
20 mounted. The balanced exciter has the same dimension and  
resistance as the standard exciter.

The upper curve has been raised 10dB so that the  
differences between the upper and lower curves (10,12) are  
more clear. The frequency response achieved using a  
25 balanced exciter is smoother and thus more desirable.

Figure 7 shows a graph<sup>12</sup> of impedance against frequency for the magnet assembly of a balanced exciter (for example, the exciter of Figure 2). The resonance frequency occurs at approximately 50Hz. The resonance  
5 frequency is measured as a function of impedance with a grounded voice coil.

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Fig 1 prior art

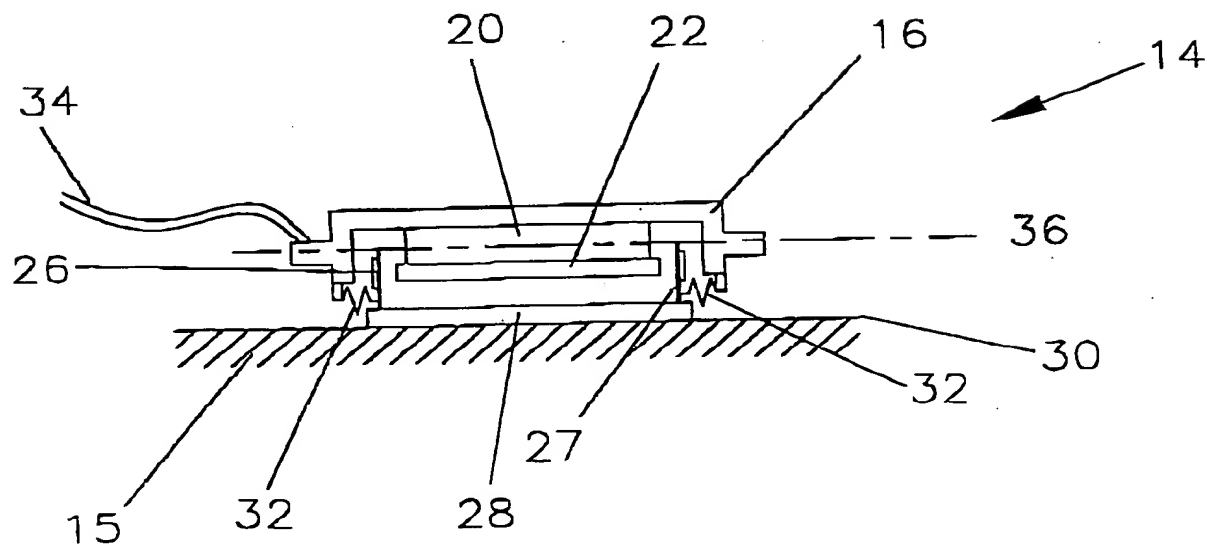
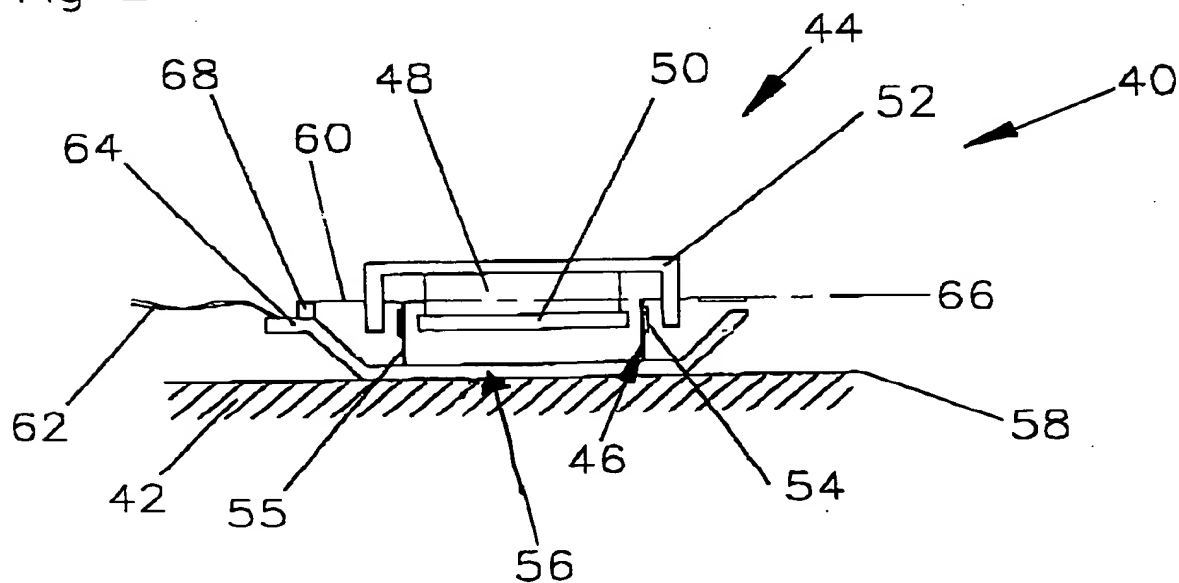


Fig 2



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Fig 3

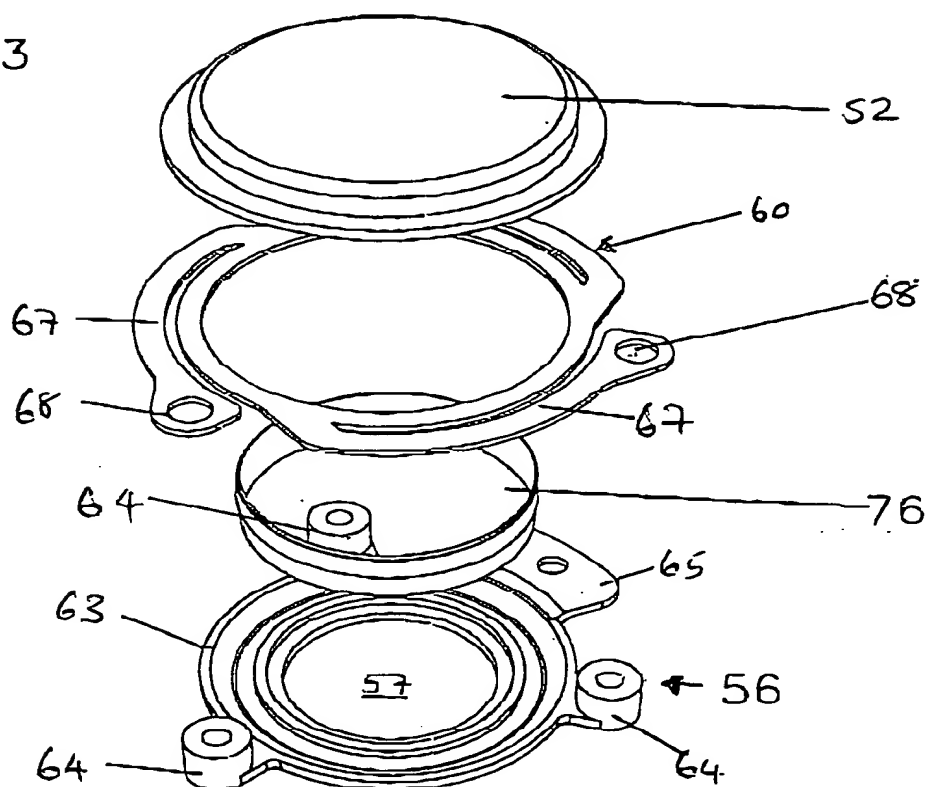
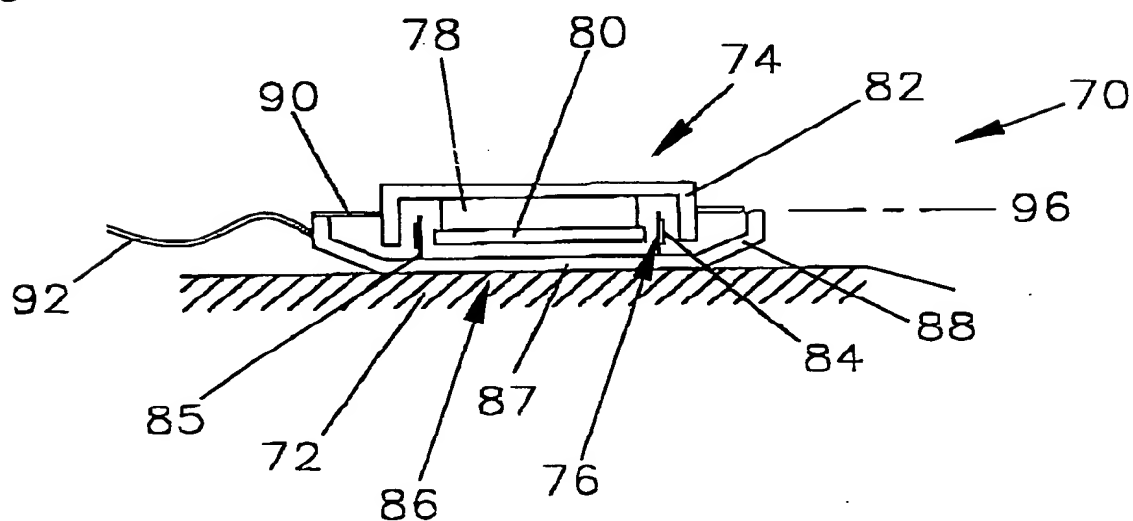


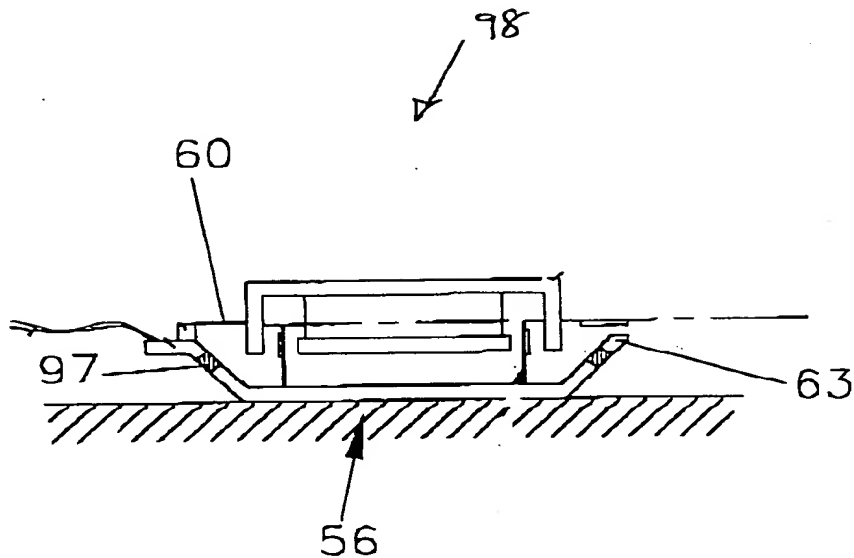
Fig 4



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Fig 5



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Fig. 6

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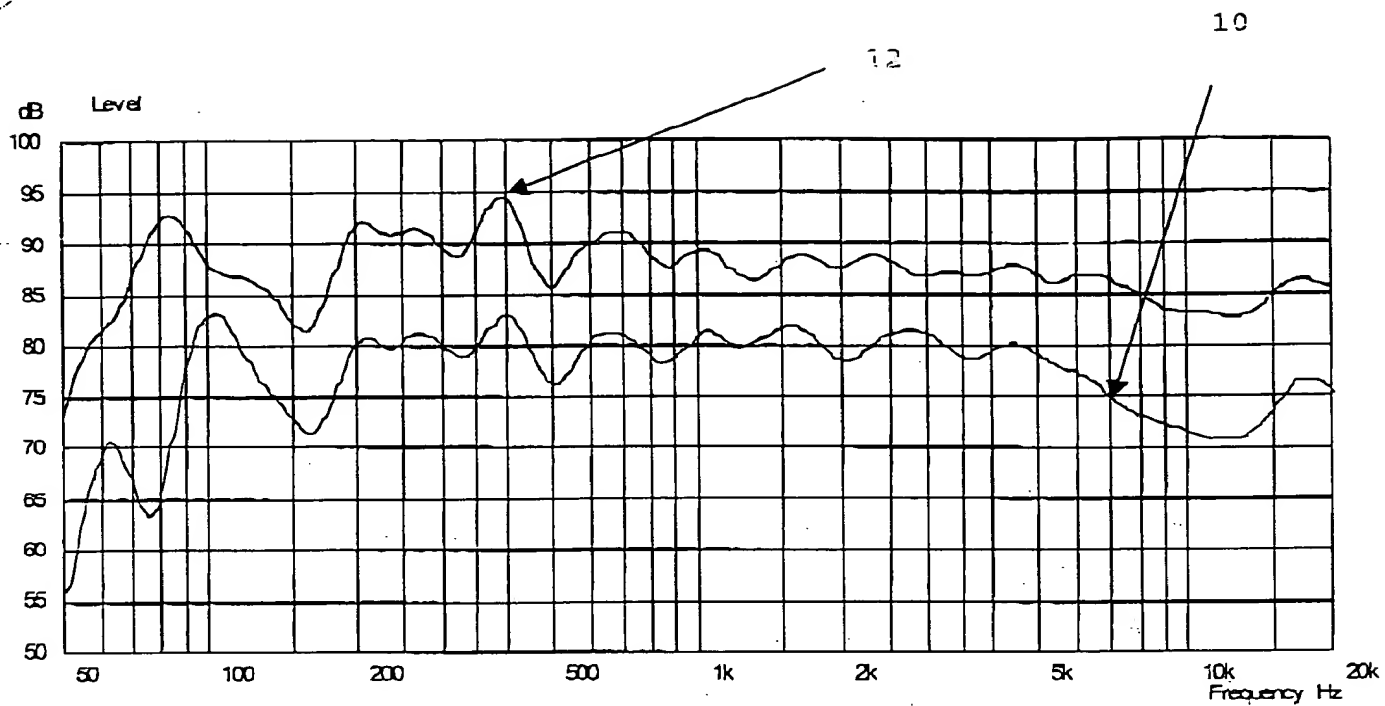
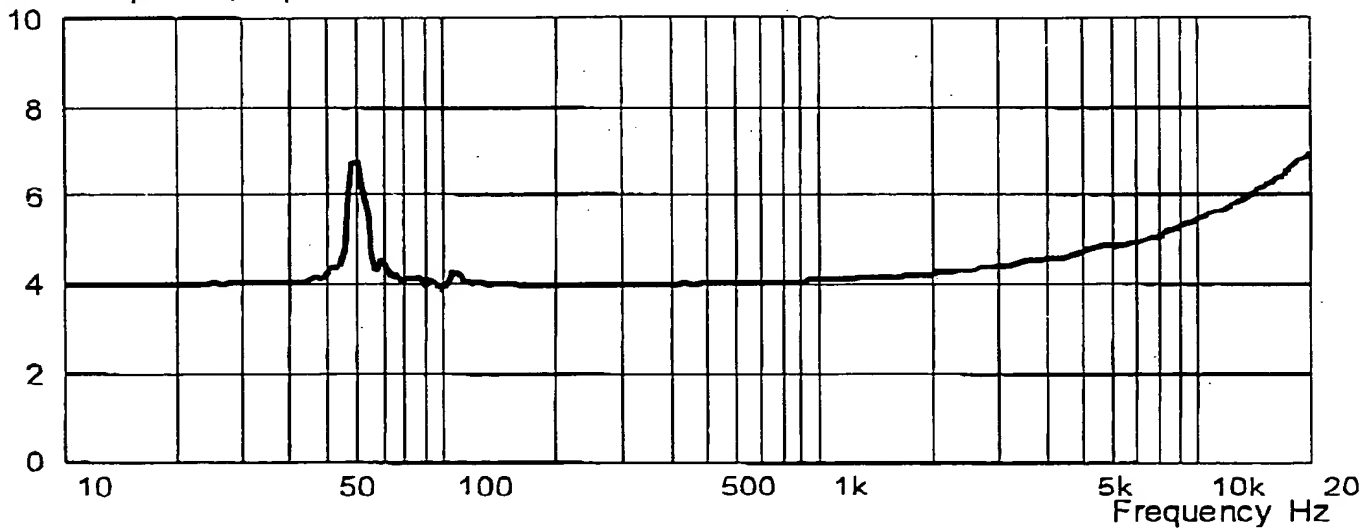


Fig. 7

ohm Amplitude, Impedance



Docket No: 085874-0381  
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